

UTILIZATION OF SUNFLOWER STALKS  
IN PAPER MANUFACTURE

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The utilization of sunflower  
stalks in paper manufacture

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THE UTILIZATION OF SUNFLOWER STALKS

IN

PAPER MANUFACTURE.

A THESIS

Presented by

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..

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## P R E F A C E.

### Part I.

The object of this part is to determine the most efficient cooking of the sunflower stalks, and beating and bleaching of the pulp, and all other experimental data connected with the process.

### Part II.

This chapter deals with the proposed process and giving an idea of the cost of operation.



## Part I.

1. Introduction.
2. Treatment -
  - a. Cooking.
  - b. Beating.
  - c. Bleaching.
  - c. Sizing.
3. Making of Sheets.
4. Results.
5. Samples of paper made.
6. Discussion.

## Part II.

1. Process.
2. Cost.



## PART I.

The Object of this part is to determine the most efficient cooking of the sunflower stalks, and beating and bleaching of the pulp, and all other experimental data connected with the process.



THE UTILIZATION OF SUNFLOWER STALKS  
IN  
PAPER MANUFACTURE.

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The object of this work is to determine whether the sunflower stalks could be economically used in the manufacture of various grades of paper. The two grades of sunflower stalks; the green stalks, (stalks cut while still green), and the natural dried stalks, (stalks cut after having started to dry), which were used in this work were obtained from Kansas. The green stalks upon arrival were dried in a steam heated closet. The sunflower stalks were cut into small chips, each variety being kept separate. The chips were divided into four groups and each group was separately treated.

Cooking of the Sunflower Stalks.

The four groups of sunflower stalks were as follows:

Group I. Consisted of green sunflower stalks; chips with the pith of the stalks removed.

Groups II and III. Consisted of natural sunflower chips with the pith of the stalks.

Group IV. Was made up of natural dried stalks with the pith removed.





The leaves of the green stalks which were dried in the dryer were removed and then the stalks were cut open and the pith removed. The stalks, after the removal of the pith, were cut up into chips of about two to three inches in length and  $1/8$  inch to  $1/4$  inch thick. .55 lbs. of chips were placed into the cooker capable of holding three liters. The stalks were covered with liquor of the following content:

NaOH	- 4%	of wgt. of stalks used	.....	12	grs.
$\text{Na}_2\text{CO}_3$	-12%	" " " "	.....	35	" .
NaCl	-10%	" " " "	.....	29	" .
NaOCl	-0.5%	" " " "	.....	1.5	" .

The liquor was made by dissolving the above substances in one liter of distilled water. Then water was added to the mixture in the cooker until the chips were well covered with water. The cooker was closed and heat was applied to it by the use of a Bunsen burner flame. The pressure in the cooker during this run was maintained at 90 to 100 lbs. per square inch. The run was made in two periods of five hours each, as it was impossible to make a ten hour run on the same day. As soon as the cooker was cold enough so that it could be easily handled, the chips were removed from it by taking off the cover and in-



verting the cooker. The chips were washed with water. The washings and the cooking liquor were saved for the determination of the recoverable alkali. The chips were now ready to be beaten in the pebble mill.

The leaves of the natural dried stalks were removed and the stalks with the pith were cut up into chips of the same size as for the previous run. Twelve ounces of these chips were placed into the cooker and used for the second run. The cooker was filled up as before, but the cooking liquor was changed to the following composition:

NaOH	-	3% of wgt. of stalks used	.....	10.23	gra.
Na <sub>2</sub> CO <sub>3</sub>	-	15% " " " "	.....	56.96	"
NaCl	-	8% " " " "	.....	27.28	"
NaOCl	-	0.25% " " " "	.....	.85	"

The stalks were cooked at a pressure of 70 lbs. per square inch for thirteen hours. The run was made in two periods; the first in nine hours and the second in four hours. At the completion of the run the liquor was drained from the stalks and saved for later use. The cooked stalks were weighed and the moisture content was determined.

The third run was performed on the same stalks as the second.  $7\frac{1}{4}$  oz. of chips were placed into the cooker and the fol-



lowing cooking mixture was added:

NaOH - 3% of wgt.of stalks used ..... 6.15 grs.

Na<sub>2</sub>CO<sub>3</sub> - 9% " " " " " .....16.4 " .

NaCl - 5% " " " " " .....10.25 " .

NaOCl - .25% " " " " " ..... .513 " .

1.36 liter of cooking liquor obtained in the second run.

The material was cooked for nine hours in two periods; one of five hours and the other of four hours, and at a pressure of 120 lbs. per square inch. At the end of the run the liquor was drained from the chips and the chips were weighed and placed into the beater. The liquor was saved for further use.

The fourth run was performed on natural dried sunflower stalks from which the pith was removed. The cooking liquor was changed. The following cooking mixture was used with 10 $\frac{1}{2}$  oz.of sunflower stalk chips:

NaOH - 5% of wgt.of stalks used ..... 14.7 grs.

Na<sub>2</sub>CO<sub>3</sub>- 12% " " " " " ..... 35.1 " .

One (1) liter of cooking liquor from the third run was also added. The mixture was cooked for fourteen hours in periods of eight and six hours. The pressure was maintained at 80 lbs.per square inch. The liquor was drained from the chips and saved for analysis and recovery of alkali.

1. The first step is to identify the problem.

2. The second step is to define the problem.

3. The third step is to analyze the problem.

4. The fourth step is to develop a solution.

5. The fifth step is to implement the solution.

6. The sixth step is to evaluate the solution.

7. The seventh step is to monitor the solution.

8. The eighth step is to report the results.

9. The ninth step is to review the process.

10. The tenth step is to document the results.

11. The eleventh step is to communicate the results.

12. The twelfth step is to conclude the project.

13. The thirteenth step is to reflect on the experience.

14. The fourteenth step is to share the results.

15. The fifteenth step is to celebrate the success.

16. The sixteenth step is to learn from the experience.

17. The seventeenth step is to apply the lessons learned.

18. The eighteenth step is to continue to improve.

19. The nineteenth step is to maintain the results.

20. The twentieth step is to end the project.

21. The twenty-first step is to close the project.

22. The twenty-second step is to archive the project.

23. The twenty-third step is to evaluate the project.

24. The twenty-fourth step is to report the results.

25. The twenty-fifth step is to conclude the project.

26. The twenty-sixth step is to reflect on the experience.

### Beating of Cooked Sunflower Stalks into Pulp.

The cooked sunflower stalks of the first run which have been washed free from alkali were divided into three equal portions. Each portion was placed into a jar and each jar was filled one-half full with pebbles, which were more egg shaped than spherical. The content in the jar was covered with water and then the jar was closed. The jars were placed upon the frame and revolved about their longitudinal axis. The jars were revolved until the pulp when suspended in water showed individual fibres. The jars had to be revolved for twenty-four hours before this stage of beating was reached. The content of each jar was now poured into a large jar and the pebbles were washed free from fibres. The water with the sunflower stalk fibres is poured on a towel and drained from fibres. The fibres or pulp was weighed and the moisture content determined.

The cooked chips of the second run were divided into three equal portions and placed into jars as those of the first run. The material was beaten for ten hours and then poured on a ten-mesh sieve and the fine pulp was washed from the pebbles and from the unbeaten stalks. The unbeaten stalks were replaced into a jar, half filled with pebbles, and the beating was continued for thirty hours. The mixture was again poured on a ten-mesh sieve and the fibres washed from the pebbles and the unbeaten stalks. The washings containing





the fibre of the sunflower stalks were poured on towels and the water drained from the fibres. The residue or pulp on the towels was weighed and the moisture determined. The unbeaten stalks were dried at 105° and weighed.

The cooked chips of the third run were divided into two equal portions and beaten for twelve hours. The mixture from the jars was poured on a ten-mesh sieve and the pebbles and the unbeaten chips were washed free from pulp. The water with the suspended pulp was poured on a towel and the pulp separated from the liquid. The mixture of the pulp was determined. The unbeaten chips were removed from the pebbles, dried at 105°C. and weighed.

As the time was short, the chips could not be beaten further, in order to have any result by the time this report had to be completed. Therefore, the chips were not beaten as much as those of the previous run.

The cooked chips of the fourth run were divided into three equal portions and placed into three jars as those of the first run. After having run the beater for three hours to one jar, 50 grams of  $\text{KMnO}_4$  were added, and the mixture beaten up for two hours longer. To the third jar, 100 grams of  $\text{KMnO}_4$  were added, and the jar replaced on the frame and the material beaten up for two hours longer. The content of the second jar was poured after seven hours of beating



on a ten-mesh sieve and then it was removed from the pebbles and stalk chips as in the previous runs. The bleached pulp of the first and third jar was treated in the same manner, only that there were no unbeaten stalks present. The moisture was determined on the pulps obtained.

#### Bleaching of the Pulp.

A definite amount of pulp from the first run was diluted with a liter of water. Chlorine gas, which was generated by  $MnO_2$  by reacting with  $HCl$  was passed into the beaker containing the diluted pulp until the pulp was fairly white.

The color of the bleached pulp was good, but the fibres were destroyed to such an extent that it was impossible to mat them on the screen. This method of bleaching was not employed in bleaching the pulp of the other three runs.

The second method of bleaching that was tried was the bleaching with bleaching powder. The powder was dissolved in water and the solution filtered. The clear filtrate was gradually added to the pulp in beaker. The pulp for bleaching was prepared as that for chlorine gas bleaching. Samples were taken at different stages during the bleaching of the pulp. This was done to see the effect the bleaching powder has upon the pulp, as it bleaches from dark brown to yellow white. This method of bleaching was also tried on the pulp of the second and third run.



The third method of bleaching tried was that of dry chlorine gas. The water was squeezed from the pulp until the pulp was fairly dry. The dry mass was placed into a flask filled with chlorine gas. The flask was stoppered and well shaken to loosen up the fibres and then it was allowed to stand over night. A part of the fibres turned to a yellowish color while most of them formed small dark lumps which were hard to break up. This method of bleaching was not tried on the subsequent runs.

The fourth method of bleaching that was tried was the one using  $\text{KMnO}_4$  as the bleaching agent. The pulp was prepared as for chlorine gas bleaching. The solution was heated and the  $\text{KMnO}_4$  was gradually added to the warm pulp mixture in the beaker. Samples were withdrawn to show different stages of bleaching and the effect of  $\text{KMnO}_4$  upon the fibre.  $\text{KMnO}_4$  was added until the solution remained violet on heating.  $\text{H}_2\text{SO}_3$  was added to the bleached pulp to remove the excess of the bleaching agent and the  $\text{MnO}_2$  formed from  $\text{KMnO}_4$  during the bleaching of the pulp. The bleaching of the pulp of the second, third and fourth runs differed from this method in that to a definite amount of pulp a definite quantity of powdered  $\text{KMnO}_4$  was added.

The fifth method of bleaching, which was tried upon the pulp of the second and third runs was that of bleaching powder followed by  $\text{KMnO}_4$ . To a definite quantity of pulp a definite amount of bleach-



ing powder solution was added. The mixture was heated for fifteen minutes and then a definite amount of powdered  $\text{KMnO}_4$  was added. The mixture was heated until the violet color of the solution had disappeared, and then  $\text{H}_2\text{SO}_3$  was added until all of the  $\text{MnO}_2$  was removed.

The sixth method of bleaching was that of combining bleaching and beating of the pulp. The cooked chips were beaten for a definite time, then to the pulp a known quantity of  $\text{KMnO}_4$  was added, and the mixture was beaten for a few hours longer. This method was tried on cooked chips of the fourth run.

#### The Sizing of the Pulp.

The rosin and aluminum-sulphate sizing was made according to the following composition:

The rosin was saponified with 16 percent sodium-hydroxide.  $\text{Al}_2(\text{SO}_4)_3$  solution was made so that 1 c.c. of the solution contained 10 percent of  $\text{Al}_2(\text{SO}_4)_3$  by weight in terms of rosin solution. That is - 10 c.c. of rosin solution contained 1 gr. of rosin and .16 gr. of  $\text{NaOH}$  and 10 c.c. of aluminum-sulphate contained .116 gr. of  $\text{Al}_2(\text{SO}_4)_3$ . The two solutions constitute one sizing. The amount of sizing used in experiment was 5 percent of the weight of the pulp. The required amount of rosin solution was added to the pulp and then the pulp was well mixed. As soon as the pulp and rosin solution were thoroughly





mixed the required amount of  $\text{Al}_2(\text{SO}_4)_3$  was added, and the solution again well mixed. Immediately after mixing, the pulp was poured upon the screen to make sheet of paper.

The albumin (white of egg) was dissolved in cold water and to it were added a few drops of concentrated solution of  $\text{NaOH}$ . This gave another sizing and it was used in the same ratio as the previous sizing.

#### Making of Sheets from Pulp.

The screen which holds the fibres and allows the water to pass through, is mounted on the lower half of the box. When the two portions of the box are placed together the screen is in the center of the box. The box is placed into a large pan containing water, so that the surface of the water stands about one-half inch above the screen. Enough pulp to make a sheet of paper was placed into a beaker and diluted with water. This was poured upon the screen. The box with the screen was gradually raised and during the raising was given a shaking motion to make a uniform sheet and to mat the fibres thoroughly. When the water was sucked through, the upper portion of the box was removed. The pulp had formed a sheet of paper and was on the screen. A blotting paper was placed on top of the sheet which was formed; then the box was inverted and the screen pressed down with the hand. The pressing



down of the screen caused the sheet of paper to part from the screen. The sheet of paper on the blotting-paper was placed under a number of blotting papers, and pressed by placing fifty pounds of iron upon it. The wet blotting papers were replaced by dry ones until the sheet of paper was dried. Each sheet formed was tested with the Mullen tester for strength.

The Mullen paper tester is a device which exerts and records the pressure required per square inch to tear the paper.



DATA AND RESULTS.

First Run:

Weight of stock used (including moisture) -----,55 lbs.

Determination of moisture:

Weight of crucible and stock : ----- 13.7811 gr.

" " " : 12.5821 gr.

Weight of stock: 1.1990 gr.

" " crucible, stock & moisture -----13.7811 gr.

Weight of crucible & stock after heating

at 105° C. for 3 hours: -----13.6585 gr.

Weight of Moisture: ----- .1226 gr.

$$\frac{.1226}{1.199} \times 100 = 10.2 \% \text{ moisture in stock.}$$

Obtained 1.67 lbs. of Pulp.

Moisture in Pulp.

Weight of crucible and wet pulp ----- 15.2260 gr.

" " " : 12.4228 gr.

Weight of Wet pulp: ----- 2.8032 gr.

Weight of crucible, pulp & moisture : -----15.2260 gr.

" " " & pulp after drying

for 3 hours at 105° C. -----12.8007 gr.

Weight of Moisture: ----- 2.4253 gr.

$$\frac{2.4253}{2.8032} \times 100 = 86.5 \% \text{ moisture in pulp.}$$

Yield of Pulp.

Dry stock ----- 55- (.102 x .55) = .494 lbs.

Dry pulp 1.67- (.865 x 1.67)= .22 lbs.

$$\text{Yield} = \frac{.22}{.494} = 44 \%$$



### Alkali Recovery.

Total volume of liquor = ----- 7300 c.c.

2000 c.c. of liquor evaporated and ignited. The ignited mass was taken up with water and diluted to 500 c.c.

50 c.c. of this solution were neutralized by 99.8 c.c.HCl.

1 c.c. HCl = .00339 gr. HCl.

$$\text{Wgt. of Na}_2\text{CO}_3 = \frac{\text{Na}_2\text{CO}_3 \times 99.8 \times .00339}{2 \text{ HCl}} = .49 \text{ grams.}$$

$$10 \times .49 \times 3.65 = 17.89 \text{ grams.}$$

$$\frac{17.89}{35} = 51 \% \text{ recoverable Na}_2\text{CO}_3 .$$

Titration for NaCl by AgNO<sub>3</sub> showed that there was 5% of NaCl recoverable.

### Strength of Sheets.

The percent of strength as used in the following tables was calculated as follows:

Sheet No.1 was torn when 30 lbs.per sq.in.were applied.

The thickness of sheet was .12 mm.

Then: .12 x .03939 = .0047268 inch.

$$\frac{30}{.47268} = 63.5 \% .$$





Sheets from the First-Run Pulp bleached with  $\text{KMnO}_4$ .

No.	Kind of Sheets.	Lbs. per Sq.In.	Thick- ness. mm	Per- cent Str.
1	Sheet from pulp as it came from beater:	30	.12	63.5
2	Fibre of #1 bleached with $\text{KMnO}_4$ :	50	.18	70.5
3	Fibre of #2 " " more $\text{KMnO}_4$ :	50	.13	98.0
4	Fibre of #3 " " " $\text{KMnO}_4$ :	27	.08	86.0
5	Fibre of #4 " " $\text{KMnO}_4$ until solution was violet:	47	.15	80.0
6	Fibre of #5 plus 10 c.c. Albumin sizing:	33	.08	105.0
7	Fibre of #1 " 10 c.c. " "	41	.135	79.0

Sheets from the First-Run Pulp bleached with Bleaching  
Powder Solution.

No.	Kind of Sheets.	Lbs. per Sq.In.	Thick- ness. mm	Per- cent Str.
1	Sheet from pulp as it came from beater:	38	.16	60.5
2	Fibre of #1 bleached with bleaching sol:	32	.19	44.5
3	Fibre of #2 " " more bleach- ing solution:	42	.25	42.7
4	Fibre of #3 " " " " ing solution:	32	.15	54.3
5	Fibre of #4 " " " " ing solution; until it gave whitest pulp:	15	.13	29.3
6	Fibre of #5 plus 10% $\text{CaCO}_3$ plus 10% sizing:	9	.08	28.6
7	Fibre #5 plus 10% $\text{BaSO}_4$ plus 10% sizing:	15	.20	19.0



Second Run:

Weight of stock used (air dry) .....12 oz.  
Weight of stock used (oven dry, loss 11.6%) .....10.6 oz.  
Weight of cooked chips (moist) ..... 1.825 lbs.  
Weight of cooked chips (oven dry, loss 74.2%) ... 47 lbs.  
Percent of stalks lost during cooking: ..... 29 %  
  
Weight of cooked chips sent to beater (oven dry):.452 lbs.  
Weight of first pulp removed from beater: ..... 1.281 lbs.  
Weight of 2nd.pulp removed from beater: ..... .835 lbs.  
Weight of unbeaten stalks (oven dry) ..... .017 lbs.  
Weight of first pulp (oven dry)(loss 83.3%) .... .208 lbs.  
Weight of second pulp(oven dry - loss 73%) ..... .224 lbs.  
Total weight of material recovered from beater: .449 lbs.  
Percent of stalks lost during beating: ..... 2 %  
  
Percent yield of unbleached pulp =  $\frac{.449}{.663} = \dots 68 \%$ .



### Alkali Recovery.

Total Volume of liquor: ----- 1475 c.c.

1 c.c. of liquor was titrated with  $\frac{N}{10}$   $H_2SO_4$  using phenolphthalein as indicator:

$$1 \text{ c.c. of liquor} = .5 \text{ c.c. } \frac{N}{10} H_2SO_4 .$$

1 c.c. of liquor was titrated with  $\frac{N}{10}$   $H_2SO_4$  using methyl-orange as indicator:

$$1 \text{ c.c. of liquor} = 3.6 \text{ c.c. } \frac{N}{10} H_2SO_4 .$$

Assuming that in the titration with  $H_2SO_4$  using phenolphthalein as indicator, the  $H_2SO_4$  has reacted with the NaOH present. Also that all of the  $Na_2CO_3$  has been converted during the cooking to  $NaHCO_3$  as the water extract of stalk is acid, and that the  $H_2SO_4$  in the titration using methylorange as indicator has reacted with free NaOH and the NaOH present.

Titration with  $AgNO_3$  showed that 13.15 gr. of NaCl were recoverable.

#### Reagents recoverable.

NaOH	-	2.956 gr.	-	28.8% of NaOH used.
$NaHCO_3$	-	38.410 gr.	-	43 % of $Na_2CO_3$ used.
NaCl	-	13.15 gr.	-	48.2% of NaCl used.



Weight of Pulp taken for one sheet (air dry) ----- 1.492 gr.

Weight of unbleached sheet ----- 1.420 gr.

Percent of stalk utilized in making a sheet of paper ----- 65 %

Results of Pulp derived from unbeaten stalks  
which were beaten to Pulp upon further beating.

No.		Wgt. of Sheet Oven- dry.	Per- cent of stalks used.	Lbs. per Square Inch.	Size in Inch- es.	Per cent Str.
1 <sup>x</sup>	Sheet made from unbleached pulp:	1.42	65	14	.0067	21
2 <sup>x</sup>	Pulp of #1 above partially bleached with $\text{KMnO}_4$ :	-	-	21	.0038	55
3 <sup>x</sup>	Pulp of #2 bleached with more $\text{KMnO}_4$ :	-	-	19	.0031	61.5
4 <sup>x</sup>	Pulp of #3 bleached with more $\text{KMnO}_4$ :	-	-	32	.0040	80
5	Pulp of #3 bleached with more $\text{KMnO}_4$ :	-	-	10	.00078	130
6 <sup>x</sup>	Pulp of #1 bleached with $\frac{1}{100}$ lbs. bleaching powder:	1.3	59.2	16	.0076	21.2
7 <sup>x</sup>	Pulp of #1 bleached with $\frac{1.5}{100}$ lbs. bleaching powder:	1.35	61.5	12	.0064	18.8
8 <sup>x</sup>	Pulp of #1 bleached with $\frac{2}{100}$ lbs. bleaching powder:	1.25	57.5	5	.0038	13.2
9 <sup>x</sup>	Pulp of #1 bleached with $\frac{2.5}{100}$ lbs. bleaching powder:	1.28	58.4	7	.0056	12.5
10 <sup>x</sup>	Pulp of #1 bleached with $\frac{3}{100}$ lbs. bleaching powder:	1.15	52.2	6	.0060	10
11 <sup>x</sup>	Pulp of #1 bleached with $\frac{3.57}{100}$ lbs. bleaching powder:	1.39	63.0	6	.0060	10
12 <sup>x</sup>	Pulp of #1 bleached with $\frac{1}{2}$ gr. $\text{KMnO}_4$ :	1.08	49.0	7	.0034	21
13 <sup>x</sup>	Pulp of #1 bleached with 2 gr. $\text{KMnO}_4$ :	.9	40.8	14	.0027	52
14 <sup>x</sup>	Pulp of #1 bleached with $\frac{2}{2}$ gr. $\text{KMnO}_4$ :	.7	32.0	4	.0013	30
15 <sup>x</sup>	Pulp of #1 bleached with $\frac{2}{100}$ bleaching powder plus 1 gr. $\text{KMnO}_4$ :	2.2	147	7	.0086	8

x - Samples attached on pages 22 to 24 .

X - 1.492 gr. of stalks in form of moist pulp were treated with the quantity of bleaching agent specified.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180	181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200	201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	216	217	218	219	220	221	222	223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240	241	242	243	244	245	246	247	248	249	250	251	252	253	254	255	256	257	258	259	260	261	262	263	264	265	266	267	268	269	270	271	272	273	274	275	276	277	278	279	280	281	282	283	284	285	286	287	288	289	290	291	292	293	294	295	296	297	298	299	300	301	302	303	304	305	306	307	308	309	310	311	312	313	314	315	316	317	318	319	320	321	322	323	324	325	326	327	328	329	330	331	332	333	334	335	336	337	338	339	340	341	342	343	344	345	346	347	348	349	350	351	352	353	354	355	356	357	358	359	360	361	362	363	364	365	366	367	368	369	370	371	372	373	374	375	376	377	378	379	380	381	382	383	384	385	386	387	388	389	390	391	392	393	394	395	396	397	398	399	400	401	402	403	404	405	406	407	408	409	410	411	412	413	414	415	416	417	418	419	420	421	422	423	424	425	426	427	428	429	430	431	432	433	434	435	436	437	438	439	440	441	442	443	444	445	446	447	448	449	450	451	452	453	454	455	456	457	458	459	460	461	462	463	464	465	466	467	468	469	470	471	472	473	474	475	476	477	478	479	480	481	482	483	484	485	486	487	488	489	490	491	492	493	494	495	496	497	498	499	500	501	502	503	504	505	506	507	508	509	510	511	512	513	514	515	516	517	518	519	520	521	522	523	524	525	526	527	528	529	530	531	532	533	534	535	536	537	538	539	540	541	542	543	544	545	546	547	548	549	550	551	552	553	554	555	556	557	558	559	560	561	562	563	564	565	566	567	568	569	570	571	572	573	574	575	576	577	578	579	580	581	582	583	584	585	586	587	588	589	590	591	592	593	594	595	596	597	598	599	600	601	602	603	604	605	606	607	608	609	610	611	612	613	614	615	616	617	618	619	620	621	622	623	624	625	626	627	628	629	630	631	632	633	634	635	636	637	638	639	640	641	642	643	644	645	646	647	648	649	650	651	652	653	654	655	656	657	658	659	660	661	662	663	664	665	666	667	668	669	670	671	672	673	674	675	676	677	678	679	680	681	682	683	684	685	686	687	688	689	690	691	692	693	694	695	696	697	698	699	700	701	702	703	704	705	706	707	708	709	710	711	712	713	714	715	716	717	718	719	720	721	722	723	724	725	726	727	728	729	730	731	732	733	734	735	736	737	738	739	740	741	742	743	744	745	746	747	748	749	750	751	752	753	754	755	756	757	758	759	760	761	762	763	764	765	766	767	768	769	770	771	772	773	774	775	776	777	778	779	780	781	782	783	784	785	786	787	788	789	790	791	792	793	794	795	796	797	798	799	800	801	802	803	804	805	806	807	808	809	810	811	812	813	814	815	816	817	818	819	820	821	822	823	824	825	826	827	828	829	830	831	832	833	834	835	836	837	838	839	840	841	842	843	844	845	846	847	848	849	850	851	852	853	854	855	856	857	858	859	860	861	862	863	864	865	866	867	868	869	870	871	872	873	874	875	876	877	878	879	880	881	882	883	884	885	886	887	888	889	890	891	892	893	894	895	896	897	898	899	900	901	902	903	904	905	906	907	908	909	910	911	912	913	914	915	916	917	918	919	920	921	922	923	924	925	926	927	928	929	930	931	932	933	934	935	936	937	938	939	940	941	942	943	944	945	946	947	948	949	950	951	952	953	954	955	956	957	958	959	960	961	962	963	964	965	966	967	968	969	970	971	972	973	974	975	976	977	978	979	980	981	982	983	984	985	986	987	988	989	990	991	992	993	994	995	996	997	998	999	1000	1001	1002	1003	1004	1005	1006	1007	1008	1009	1010	1011	1012	1013	1014	1015	1016	1017	1018	1019	1020	1021	1022	1023	1024	1025	1026	1027	1028	1029	1030	1031	1032	1033	1034	1035	1036	1037	1038	1039	1040	1041	1042	1043	1044	1045	1046	1047	1048	1049	1050	1051	1052	1053	1054	1055	1056	1057	1058	1059	1060	1061	1062	1063	1064	1065	1066	1067	1068	1069	1070	1071	1072	1073	1074	1075	1076	1077	1078	1079	1080	1081	1082	1083	1084	1085	1086	1087	1088	1089	1090	1091	1092	1093	1094	1095	1096	1097	1098	1099	1100	1101	1102	1103	1104	1105	1106	1107	1108	1109	1110	1111	1112	1113	1114	1115	1116	1117	1118	1119	1120	1121	1122	1123	1124	1125	1126	1127	1128	1129	1130	1131	1132	1133	1134	1135	1136	1137	1138	1139	1140	1141	1142	1143	1144	1145	1146	1147	1148	1149	1150	1151	1152	1153	1154	1155	1156	1157	1158	1159	1160	1161	1162	1163	1164	1165	1166	1167	1168	1169	1170	1171	1172	1173	1174	1175	1176	1177	1178	1179	1180	1181	1182	1183	1184	1185	1186	1187	1188	1189	1190	1191	1192	1193	1194	1195	1196	1197	1198	1199	1200	1201	1202	1203	1204	1205	1206	1207	1208	1209	1210	1211	1212	1213	1214	1215	1216	1217	1218	1219	1220	1221	12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Results of Pulp from the First  
Beating of Cooked Stalks.

No.		Lbs. per Sq.In.	Size. <small>THICK</small>	Per cent Str.
1 x	Sheet made from unbleached pulp:	7.5	.09	21
2	To 12.2 gr.of pulp calculated even dry added 1 gr. $KMnO_4$ :	15.	.14	27.1
3	To 12.2 gr.of pulp calculated " dry added 2 gr. $KMnO_4$ :	24.2	.22	27.8
4	To 12.2 gr.of pulp calculated " dry added 3 gr. $KMnO_4$ :	51.5	.28	46.9
5	To 12.2 gr.of pulp calculated " dry added 5 gr. $KMnO_4$ :	26	.11	59.8
6 x	To 12.2 gr.of pulp calculated " dry added 8 gr. $KMnO_4$ :	22.5	.07	81.5
7 x	To 12.2 gr.of pulp calculated " dry added 11 gr. $KMnO_4$ :	32	.08	102
8 x	To 12.2 gr.of pulp calculated " dry added 14 gr. $KMnO_4$ :	11	.02	140
10 <sup>x</sup>	To 12.2 gr.of pulp calculated " dry added $KMnO_4$ until excess:	7	.06	31

Samples attached on Pages 24 and 25.



### Third Run:

Weight of stock used (air dry) -----  $7\frac{1}{4}$  oz.  
Weight of stock used (calculated over dry, loss 11.6%) ----- 6.5 oz.  
Weight of cooked chips (moist) ----- 16.5 oz.  
Weight of cooked chips (oven dry - loss 73%) ----- 4.45 oz.  
Percent of stalks lost during cooking ----- 31.50 oz.  
Weight of cooked chips sent to beater (oven dry) ----- 4.0 oz.  
Weight of first pulp removed from beater: ----- 10.33 oz.  
Weight of unbeaten stalks oven dry ----- 1.36 oz.  
Weight of first pulp calculated oven dry ----- 2.14 oz.  
Total weight of material: ----- 3.50 oz.  
Percent of stalks lost during beating: ----- 12.5 %  
Percent yield of unbleached pulp possible if the stalks  
were also beaten to pulp: ----- 56 %

### Alkali Recovery.

Total volume of liquor: ----- 1400 c.c.

1 c.c. of liquor = .3 c.c.  $\frac{N}{10}$  H<sub>2</sub>SO<sub>4</sub>; phenolphthalein indicator.

1 c.c. of liquor = 3.5 c.c.  $\frac{N}{10}$  H<sub>2</sub>SO<sub>4</sub>; methyl-orange " "

5 c.c. of liquor = .1693 gr. AgCl.

### Reagents recoverable.

NaOH	-	2.38 gr.	-	28.3 % of NaOH
NaHCO <sub>3</sub>	-	37.53 gr.	-	61.3 % of Na <sub>2</sub> CO <sub>3</sub>
NaCl	-	19.04 gr.	-	83.5 % of NaCl



Results of Pulp of Third Run.

No.		Wgt. of Sheet Oven- Dry.	Per cent of stalks used.	Lbs. per Sq. In.	Size in Inch- es.	Per- cent Str.
1 x	Sheet made from unbleached pulp:	1.31	51	10	.0096	10.3
	To 1.44 gr. of dry pulp -					
2	added 1/2 gr. $KMnO_4$ :	1.11	43	5	.0053	9.5
3	" 1 gr. "	1.13	44	5	.0015	33.
4	" 1 1/2 gr. "	.84	32	4	.0014	28.5
5	" 2 gr. "	.92	35	5	.0014	35.6
6	" 2 1/2 gr. "	.82	31.8	4	.0012	33.2
7	" 3 gr. "	.82	31.8	3	.0008	37.5
8	" 1 lbs. of bleaching 100 powder:	1.27	49.1	6	.011	5.1
9	" 1.5 lbs. " " "	1.31	51.	5	.007	7.1
10	" 2 lbs. " " "	1.26	49	4	.012	3.3
11	" 2.5 lbs. " " "	1.19	46	5	.008	6.25
12	" 3 lbs. " " "	1.31	51	4	.0046	8.75
13	" 3.5 lbs. " " "	1.14	44.5	-	-	-
14	" 4 lbs. " " "	1.13	44.	8	.0042	19.5
15	" 1.1 lbs. " " "	1.05	40.8	-	-	-
16 x	" 1.1 lbs. " " " 10 plus 3/4 gr. $KMnO_4$ :	1.25	43.	4	.0036	11.2

x - Samples attached on Page 26.



#### Fourth Run:

Weight of stock used (air dry) ----- 10.5 oz.  
" " " " (calc. on oven dry, loss 12.1%) ----- 9.1 oz.  
Weight of cooked chips (moist) ----- 21-1/8 oz.  
" " " " (oven dry, loss 63.8%) ----- 7.7 oz.  
Percent of stalks lost during cooking: ----- 15.3%  
Weight of cooked chips beaten in the jar mill ----- 6.89 oz.  
Weight of pulp obtained from Jar I to which 50 gr. of  
KMnO<sub>4</sub> was added: ----- 8.00 oz.  
Weight of pulp obtained from Jar III to which 100 gr. of  
KMnO<sub>4</sub> was added: ----- 4-3/8 oz.  
Weight of pulp obtained from Jar II to which no bleach-  
ing agent was added: ----- 7.5 oz.  
Weight of unbeaten stalks from Jar II oven dry: ----- .5 oz.  
Weight of pulp from Jar I oven dry: ----- 1.08 oz.  
Weight " " " " III " " : ----- .95 oz.  
Weight " " " " II " " : ----- 1.24 oz.  
Total pulp accounted: ----- 3.77 oz.  
Percent of stalks converted to pulp: ----- 48.4 %

#### Alkali Recovery.

Total volume of liquor : ----- 1750 c.c.  
1 c.c. of liquor = .15 c.c.  $\frac{N}{10}$  H<sub>2</sub>SO<sub>4</sub> - phenolphthalein indicator.  
1 c.c. " " = 4.3 c.c.  $\frac{N}{10}$  H<sub>2</sub>SO<sub>4</sub> - methyl-orange "  
5 c.c. " " = .0663 gr. AgCl.

#### Reagents Recoverable.

NaOH	-	1.05 gr.	-	6.3 % of NaOH
NaHCO <sub>3</sub>	-	61.0 gr.	-	31.2 % of Na <sub>2</sub> CO <sub>3</sub>
NaCl	-	9.45 gr.	-	69.5 % of NaCl

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180	181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200	201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	216	217	218	219	220	221	222	223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240	241	242	243	244	245	246	247	248	249	250	251	252	253	254	255	256	257	258	259	260	261	262	263	264	265	266	267	268	269	270	271	272	273	274	275	276	277	278	279	280	281	282	283	284	285	286	287	288	289	290	291	292	293	294	295	296	297	298	299	300	301	302	303	304	305	306	307	308	309	310	311	312	313	314	315	316	317	318	319	320	321	322	323	324	325	326	327	328	329	330	331	332	333	334	335	336	337	338	339	340	341	342	343	344	345	346	347	348	349	350	351	352	353	354	355	356	357	358	359	360	361	362	363	364	365	366	367	368	369	370	371	372	373	374	375	376	377	378	379	380	381	382	383	384	385	386	387	388	389	390	391	392	393	394	395	396	397	398	399	400	401	402	403	404	405	406	407	408	409	410	411	412	413	414	415	416	417	418	419	420	421	422	423	424	425	426	427	428	429	430	431	432	433	434	435	436	437	438	439	440	441	442	443	444	445	446	447	448	449	450	451	452	453	454	455	456	457	458	459	460	461	462	463	464	465	466	467	468	469	470	471	472	473	474	475	476	477	478	479	480	481	482	483	484	485	486	487	488	489	490	491	492	493	494	495	496	497	498	499	500	501	502	503	504	505	506	507	508	509	510	511	512	513	514	515	516	517	518	519	520	521	522	523	524	525	526	527	528	529	530	531	532	533	534	535	536	537	538	539	540	541	542	543	544	545	546	547	548	549	550	551	552	553	554	555	556	557	558	559	560	561	562	563	564	565	566	567	568	569	570	571	572	573	574	575	576	577	578	579	580	581	582	583	584	585	586	587	588	589	590	591	592	593	594	595	596	597	598	599	600	601	602	603	604	605	606	607	608	609	610	611	612	613	614	615	616	617	618	619	620	621	622	623	624	625	626	627	628	629	630	631	632	633	634	635	636	637	638	639	640	641	642	643	644	645	646	647	648	649	650	651	652	653	654	655	656	657	658	659	660	661	662	663	664	665	666	667	668	669	670	671	672	673	674	675	676	677	678	679	680	681	682	683	684	685	686	687	688	689	690	691	692	693	694	695	696	697	698	699	700	701	702	703	704	705	706	707	708	709	710	711	712	713	714	715	716	717	718	719	720	721	722	723	724	725	726	727	728	729	730	731	732	733	734	735	736	737	738	739	740	741	742	743	744	745	746	747	748	749	750	751	752	753	754	755	756	757	758	759	760	761	762	763	764	765	766	767	768	769	770	771	772	773	774	775	776	777	778	779	780	781	782	783	784	785	786	787	788	789	790	791	792	793	794	795	796	797	798	799	800	801	802	803	804	805	806	807	808	809	810	811	812	813	814	815	816	817	818	819	820	821	822	823	824	825	826	827	828	829	830	831	832	833	834	835	836	837	838	839	840	841	842	843	844	845	846	847	848	849	850	851	852	853	854	855	856	857	858	859	860	861	862	863	864	865	866	867	868	869	870	871	872	873	874	875	876	877	878	879	880	881	882	883	884	885	886	887	888	889	890	891	892	893	894	895	896	897	898	899	900	901	902	903	904	905	906	907	908	909	910	911	912	913	914	915	916	917	918	919	920	921	922	923	924	925	926	927	928	929	930	931	932	933	934	935	936	937	938	939	940	941	942	943	944	945	946	947	948	949	950	951	952	953	954	955	956	957	958	959	960	961	962	963	964	965	966	967	968	969	970	971	972	973	974	975	976	977	978	979	980	981	982	983	984	985	986	987	988	989	990	991	992	993	994	995	996	997	998	999	1000	1001	1002	1003	1004	1005	1006	1007	1008	1009	1010	1011	1012	1013	1014	1015	1016	1017	1018	1019	1020	1021	1022	1023	1024	1025	1026	1027	1028	1029	1030	1031	1032	1033	1034	1035	1036	1037	1038	1039	1040	1041	1042	1043	1044	1045	1046	1047	1048	1049	1050	1051	1052	1053	1054	1055	1056	1057	1058	1059	1060	1061	1062	1063	1064	1065	1066	1067	1068	1069	1070	1071	1072	1073	1074	1075	1076	1077	1078	1079	1080	1081	1082	1083	1084	1085	1086	1087	1088	1089	1090	1091	1092	1093	1094	1095	1096	1097	1098	1099	1100	1101	1102	1103	1104	1105	1106	1107	1108	1109	1110	1111	1112	1113	1114	1115	1116	1117	1118	1119	1120	1121	1122	1123	1124	1125	1126	1127	1128	1129	1130	1131	1132	1133	1134	1135	1136	1137	1138	1139	1140	1141	1142	1143	1144	1145	1146	1147	1148	1149	1150	1151	1152	1153	1154	1155	1156	1157	1158	1159	1160	1161	1162	1163	1164	1165	1166	1167	1168	1169	1170	1171	1172	1173	1174	1175	1176	1177	1178	1179	1180	1181	1182	1183	1184	1185	1186	1187	1188	1189	1190	1191	1192	1193	1194	1195	1196	1197	1198	1199	1200	1201	1202	1203	1204	1205	1206	1207	1208	1209	1210	1211	1212	1213	1214	1215	1216	1217	1218	1219	1220	1221	12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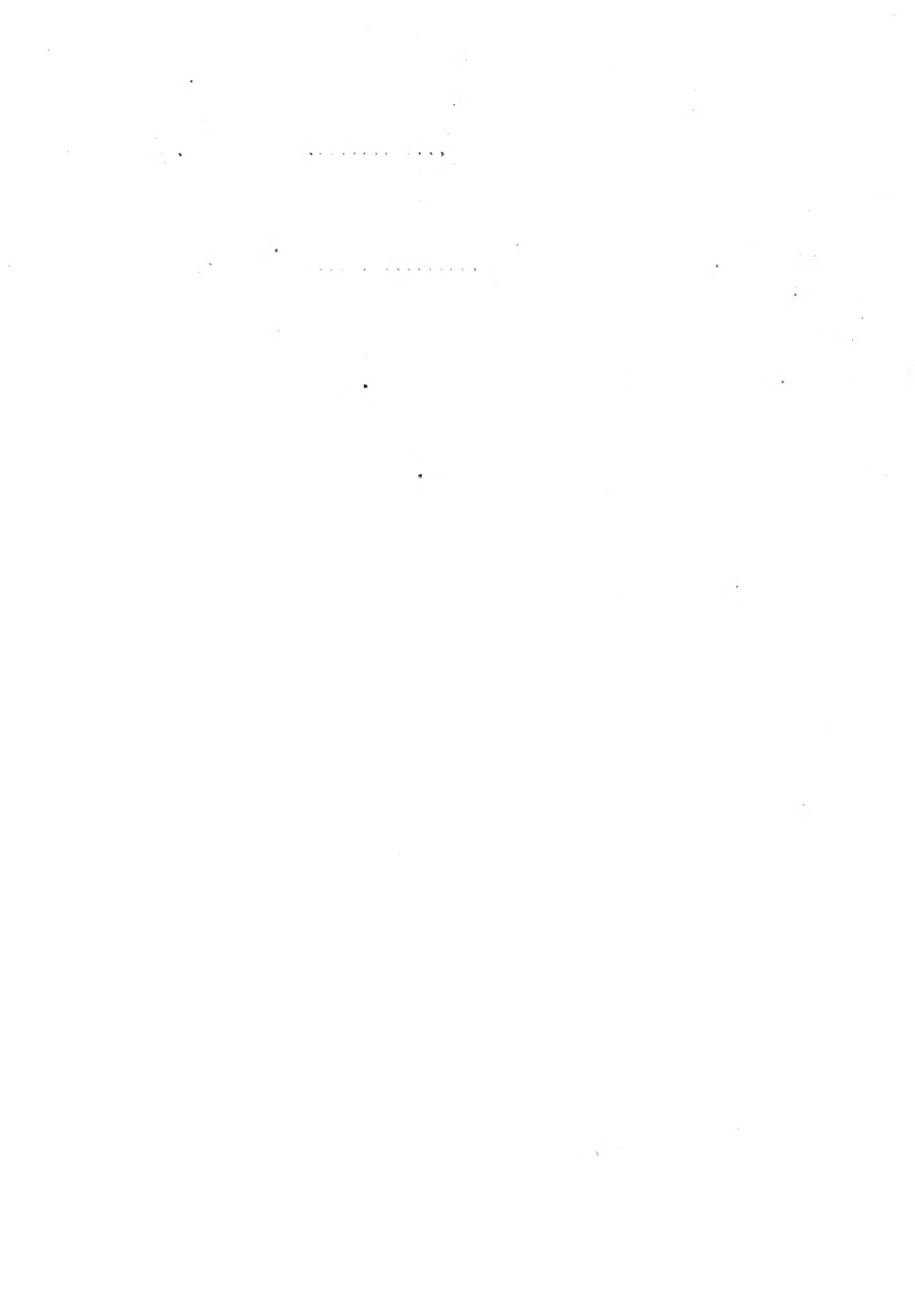


Sheets made from unbleached pulp are .....19 % strong. x

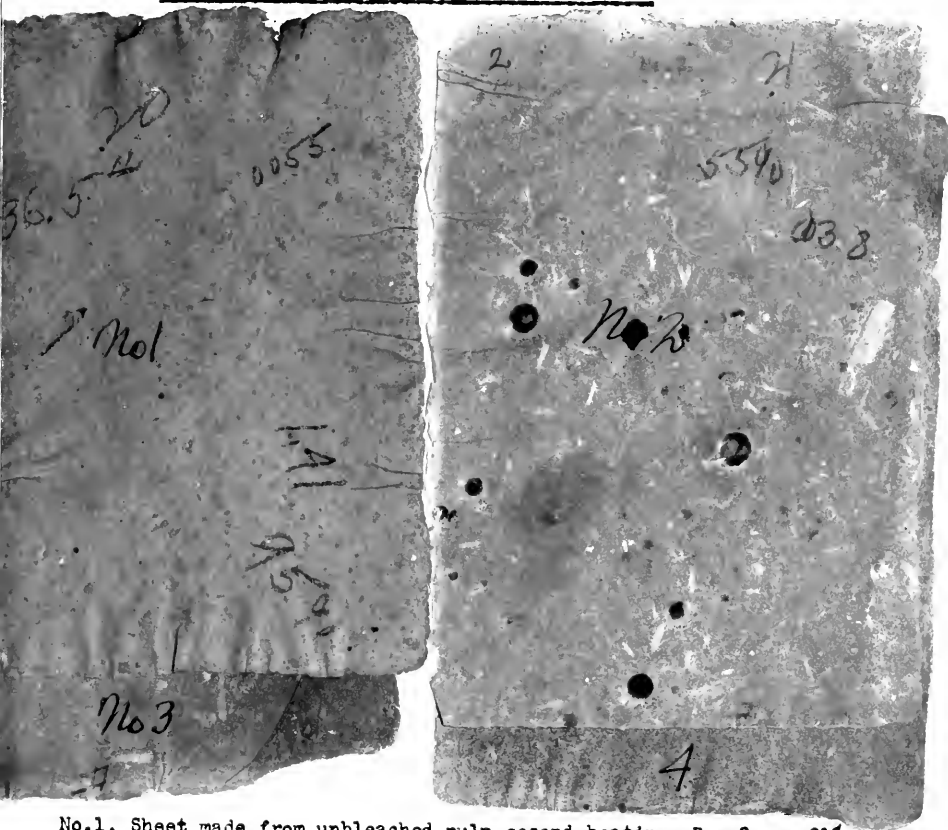
Sheets made from bleached pulp, bleached by  
adding 50 gr.  $\text{KMnO}_4$  to the jar are..... 64% " x

Sheets made from pulp which was bleached with  
100 gr.  $\text{KMnO}_4$  are brittle and fall to pieces.

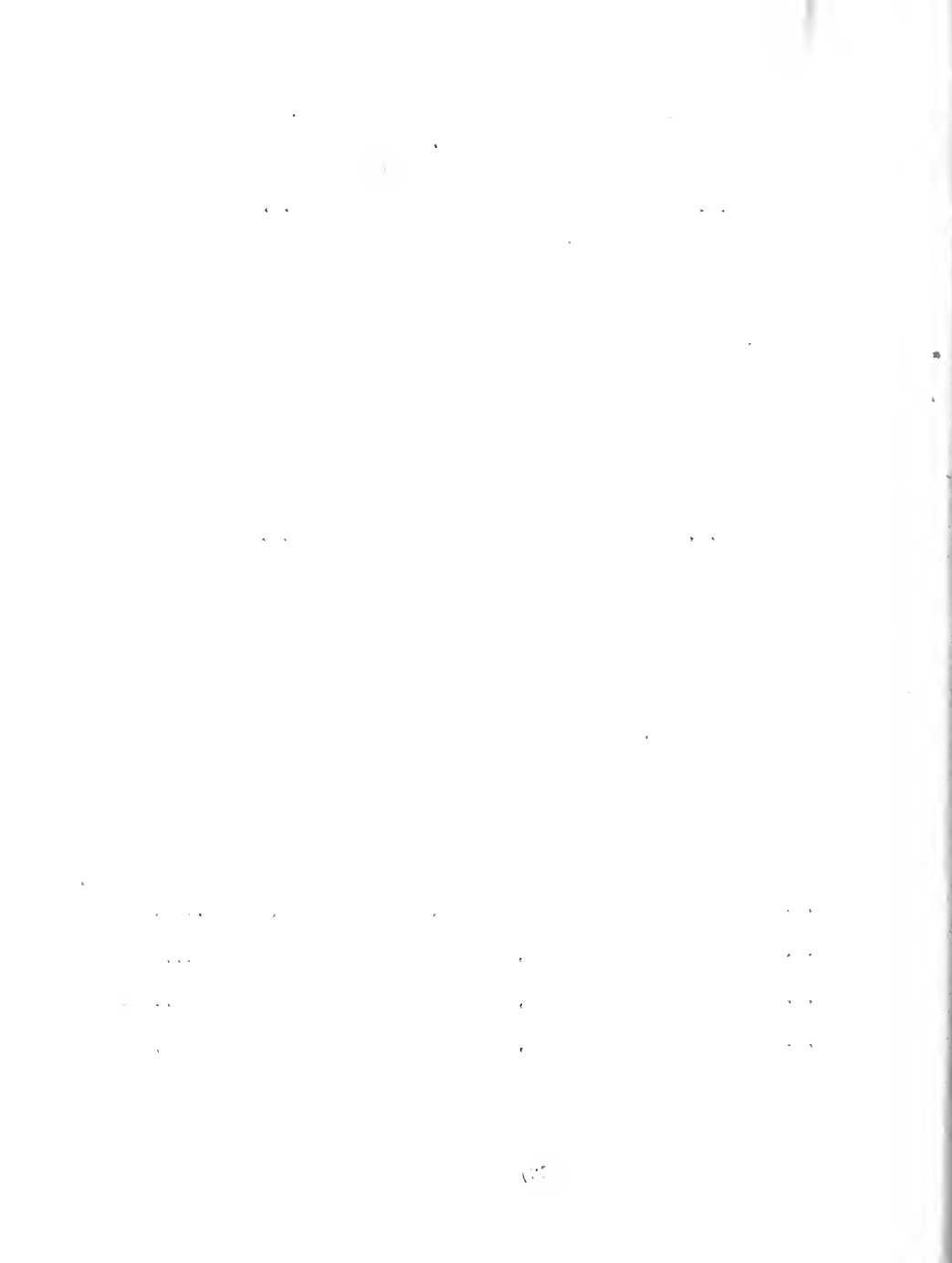
x - Samples attached to pages 25 and 26.



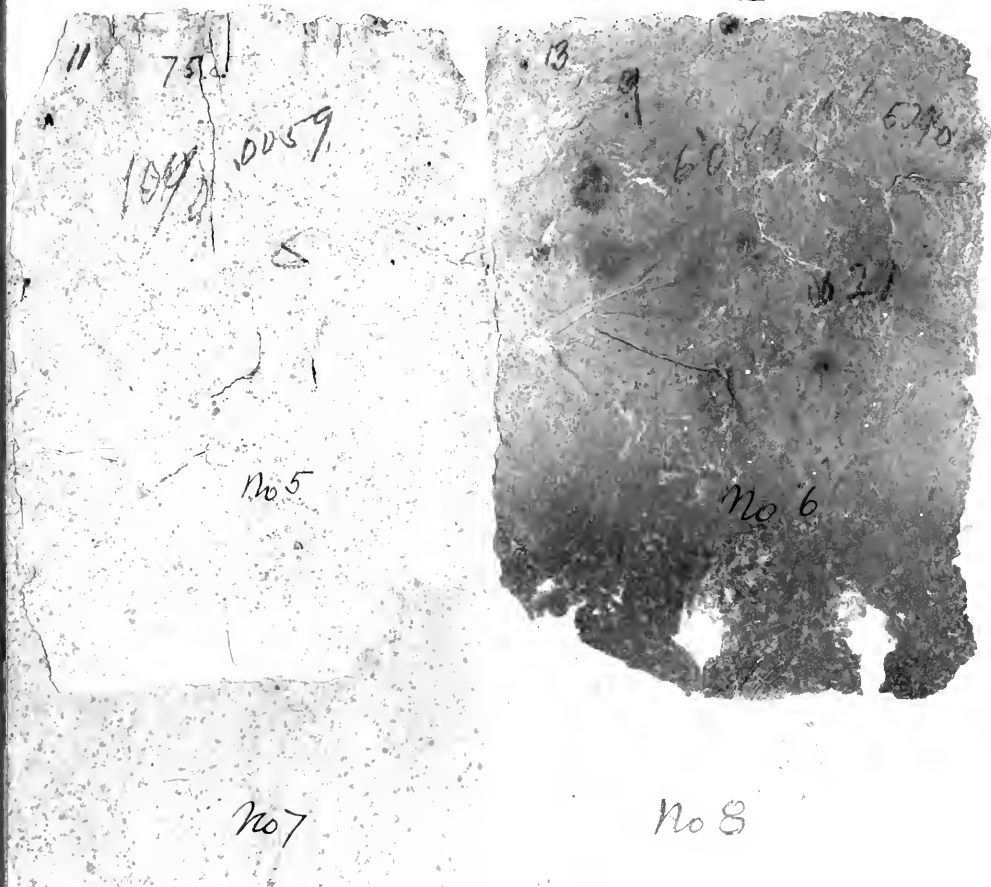
Samples from Pulp of Second Run obtained  
from second beating of stalks.



- No.1. Sheet made from unbleached pulp, second beating, Run 2.....21%
- No.2. " " " #1 pulp, partially bleached with  $\text{KMnO}_4$  ....55%
- No.3. " " " #2 " , bleached with more  $\text{KMnO}_4$  .....61.5%
- No.4. " " " #3 " , " " "  $\text{KMnO}_4$  .....30%

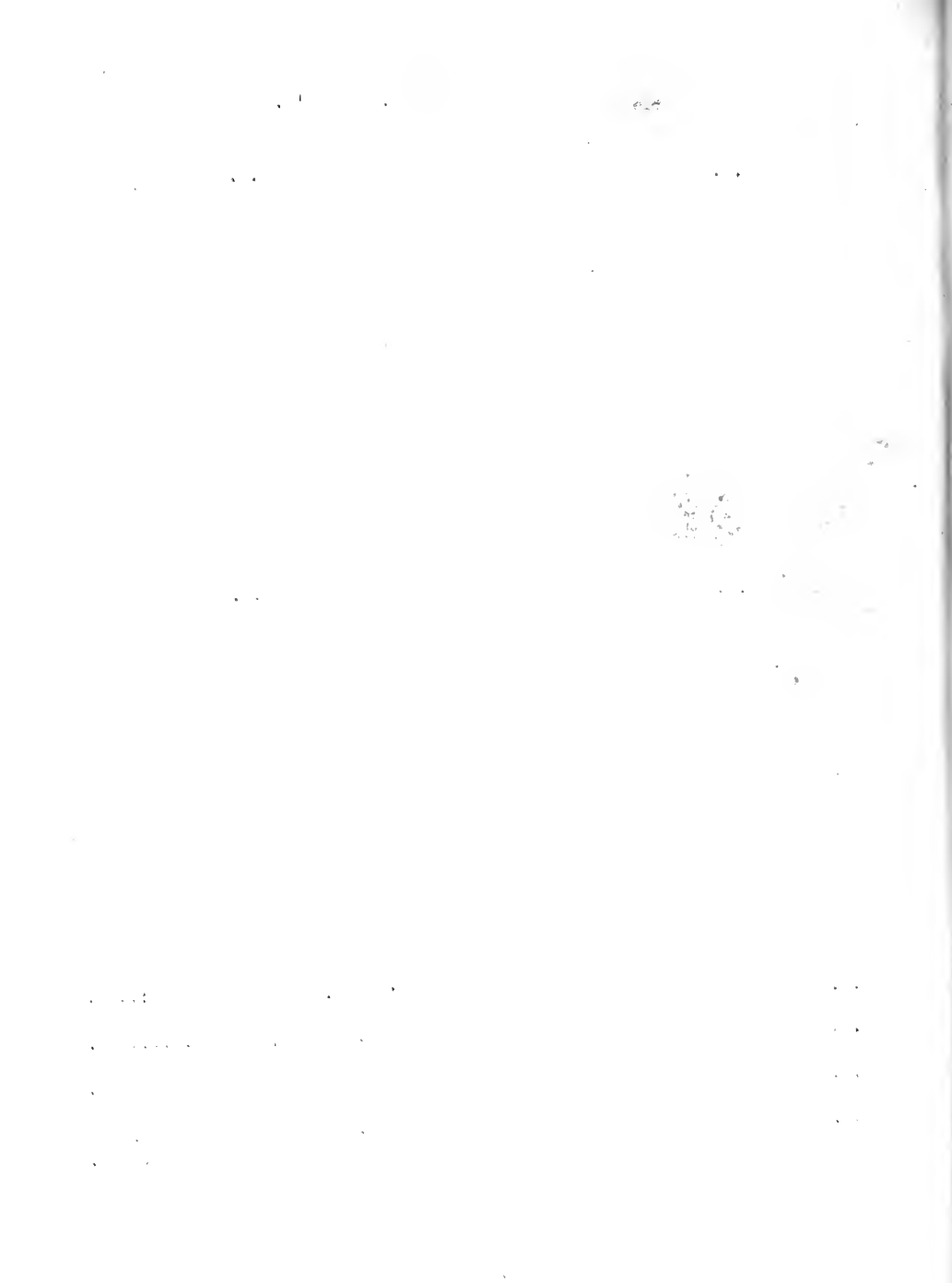


Samples from Pulp of Second Run obtained  
from second beating of Stalks. Cont'd.

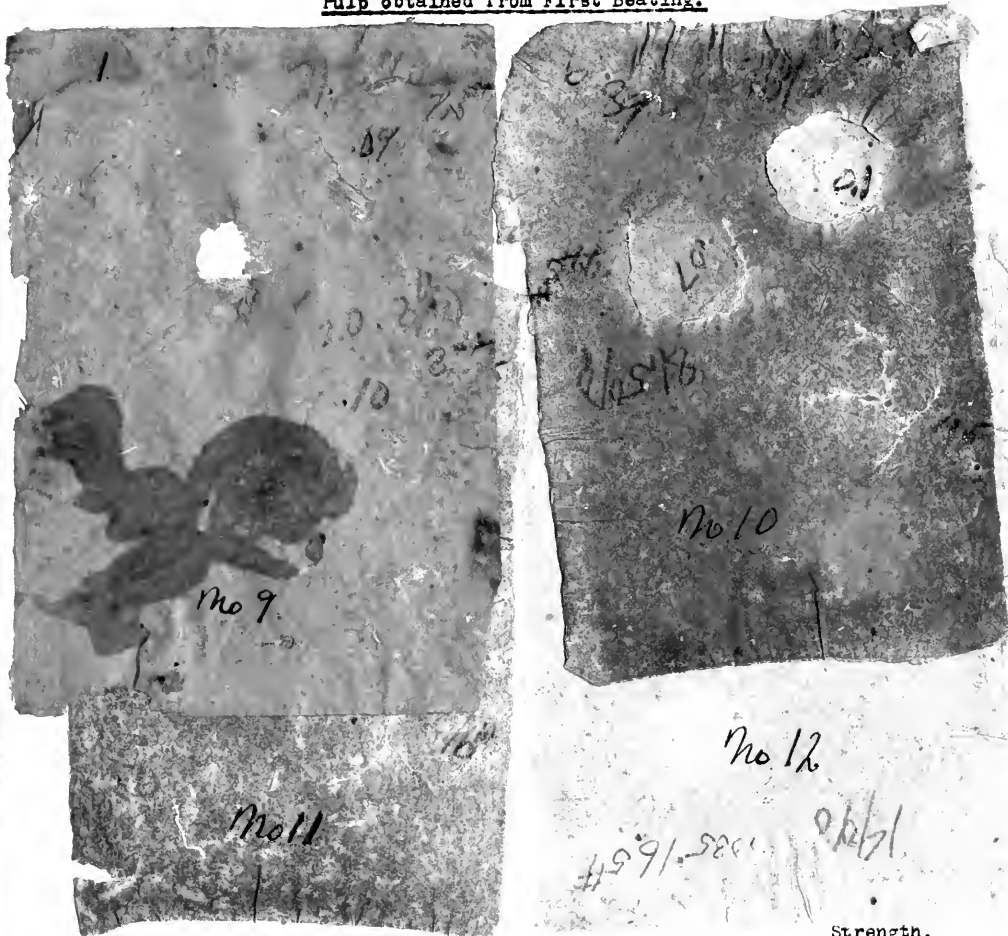


Strength.

No. 5.	Sheet	made	from	#1	pulp	bleached	with	$\frac{3.57}{100}$	lb. bleaching powder:.....	10%
No. 6.	"	"	"	#1	"	"	"	2 gr. $\text{KMnO}_4$ .....	52%	
No. 7.	"	"	"	#1	"	"	"	$2\frac{1}{2}$ gr. $\text{KMnO}_4$ .....	30%	
No. 8.	"	"	"	#1	"	"	"	1 gr. $\text{KMnO}_4$ and 2/100 lbs. bleaching powder: .....	8%	



Pulp obtained from First Beating.



Strength.

No.9.	Sheet	made	from	unbleached	pulp	.....	21%
No.10.	"	"	"	12.2 gr. of pulp	bleached with 8 gr. $KMnO_4$	..	81.5%
No.11.	"	"	"	12.2 gr. "	"	" 11 gr. $KMnO_4$	.. 102%
No.12.	"	"	"	12.2 gr. "	"	" 14 gr. $KMnO_4$	.. 140%





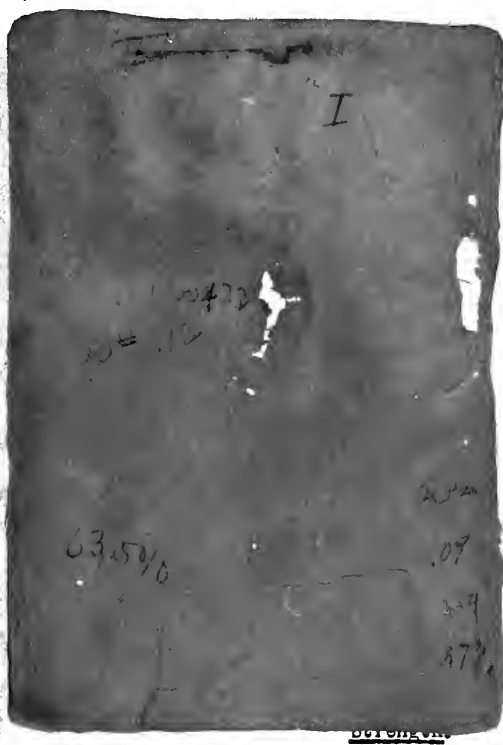
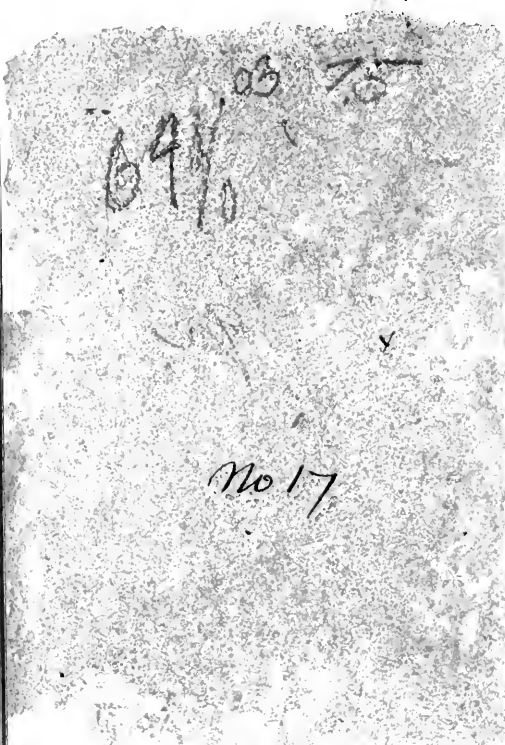


Strength.

- No.13. Sheet made by bleaching 12.2 gr.of pulp of Sample #9  
with  $\text{KMnO}_4$  till solution became violet: .....31%  
No.14. Sheet made from unbleached pulp of third run :.....10.3%  
No.15. Sheet made from 1.44 gr.of pulp of third run bleached with  
1.1 lbs.bleaching powder plus  $3/4$  gr. $\text{KMnO}_4$  .....11.2%  
10  
No.16. Sheet made from unbleached pulp of fourth run: .....19%



Pulp obtained from First Beating.  
(Continued.)



- No.17. Sheet made from Pulp bleached by adding 50 gr.of  $\text{KMnO}_4$   
into the jar while the stalk was beaten to a pulp: .....64%
- No.18. Sheet made from Pulp of run No.1: .....63.5%



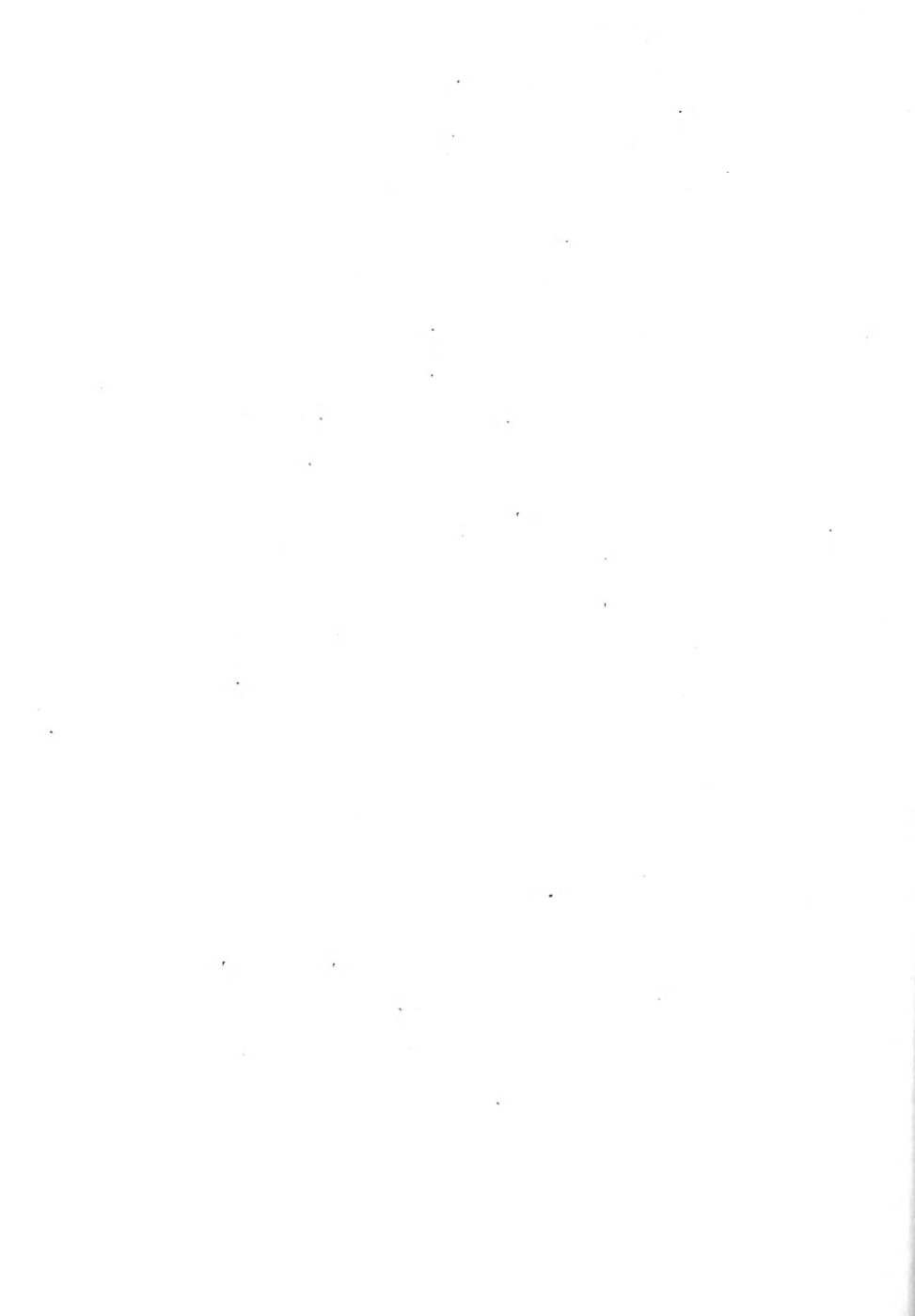
## DISCUSSION.

From the results obtained I believe that we could get better grade of paper from green stalks than from natural dried stalks. By bleaching the pulp the strength is increased to a certain point and then it decreases with the addition of the bleaching agent. This can be best seen from results of first and second run. The best cooking pressure is between 70 and 100 lbs. per square inch. When the stalks were cooked at a pressure higher than 120 lbs. per square inch the fibres were destroyed, as it is well shown by the results of the third run. The addition of sizing increases the strength of the sheets.

The lumps in the sheets could be avoided if the sheets were made from pulp as it came from the beater; but as the yield had to be determined the water had to be squeezed from the pulp. By squeezing the water from the pulp the fibres were brought so close together that upon diluting with water they could not be broken up.

From results obtained it is evident that the pulp can not be bleached with bleaching powder, chlorine, under the conditions the bleaching was tried.

The pulp can be bleached with  $\text{KMnO}_4$ , but the bleaching will not be economical. Parchment paper can be made from the



pulp by bleaching the pulp with  $\text{KMnO}_4$ .

From the data at hand the sunflower stalks can be used only for the manufacture of unbleached paper, such as wrapping paper or craft paper.





## PART II.

This chapter deals with the proposed process  
and giving an idea of the cost of operation.



### The Proposed Process.

The sunflower stalks are cut when they are fresh and green, a few weeks before they begin to dry out. They are to be dried in a steam heated closet, and when they are dry, they are to be shredded. The shredded material is to be cooked with the following cooking mixture:

NaOH - 5% of weight of stalks used.

Na<sub>2</sub>CO<sub>3</sub> - 10% of " " " "

NaCl - 8% of " " " "

NaOCl - .25% of " " " "

Liquor drained from stalks.

The material is to be cooked in a steam-heated kettle at a pressure of 70 to 90 lbs. per sq. in. The cooking will be accomplished in ten hours.

The cooked material is to be beaten in a jar-mill until the fibres are separated. The stalks placed into the mill shall be five to ten percent by volume of the pebbles used. The jar shall be only one-third full filled with pebbles, and enough water added to cover the pebbles and the stalks.

If the pulp is to be bleached the bleaching agent shall be added to the pulp in the mill just before it is ready to be removed. Pulp shall then be treated according to the present practice of making paper from the pulp.



C o s t.

Original Investment, including buildings  
and complete equipment: ..... \$200,000.00

Running Expenses per Day.

Man in charge of Fourdrinier Machine: .....	\$6.67
Two assistants to above, each \$20.00 a wk: ..	6.67
Cost of one shift: .....	<u>\$13.34</u>
Cost, two shifts: .....	\$26.68
Man in charge of Beaters: .....	\$4.17
Two assistants to above, each \$2.25 a day: ..	4.50
Two laborers: .. " \$1.75 " " ...	3.50
Total per shift: .....	<u>\$12.17</u>
Cost, two shifts: .....	\$24.34
Man in charge of Cookers: .....	\$4.17
Two laborers: \$1.75 a day: .....	3.50
Cost per shift: .....	<u>\$7.67</u>
Cost, two shifts: .....	\$15.34
Man in charge of Boiler Room: .....	\$4.00
One laborer: .....	1.75
Cost per shift: .....	<u>\$5.75</u>
Cost, two shifts: .....	\$11.50
General Sup't: .....	\$20.00
One (1) Chemist: .....	5.00
Office Force: .....	<u>\$10.00</u>
Total Cost Labor per Day: .....	\$112.86



Cost of Material.

50 tons of raw material at \$5.00, at plant .....	\$250.00
Sodium-hydroxide (NaOH) .05 x 100000 x 2: .....	100.00
Sodium-Carbonate ( $\text{Na}_2\text{CO}_3$ ) .1 x 100000 x .6 : .....	60.00
Sodium-Chloride (NaCl ) .08 x 100000 x .0075 .....	60.00
Sodium-Hypochloride ( $\text{NaOCl}$ ) .0025 x 100000 x .0725 ...	16.13

Sizing:

1890 lbs. Rosin	at 1.35¢ per lb. ....	\$ 25.66
360 lbs. NaOH	" .02¢ " " .....	7.20
250 lbs. $\text{Al}_2(\text{SO}_4)_3$	" 1 $\frac{1}{4}$ ¢ " " .....	3.13

Other Charges.

Interest at 6% .....	\$33.34
Depreciation at 6% .....	33.34
Taxes: .....	2.78
Insurance: .....	2.78
Coal: .....	50.00

Total Cost: \$759.22





Total paper produced .....50,000 lbs.

Cost of Unbleached Paper: Per Lbs: .....1.52 cts.

Cost of Light Yellow Paper:

Cost of Unbleached paper .....1.52 cts.  
50% of wgt.of pulp,  $\text{KMnO}_4$  as bleaching  
agent: .....5.00 cts.  

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Cost of light yellow paper: 6.52 cts. per lb.

Cost of White Paper:

1.66 lbs.of unbleached pulp required  
to make 1 lb. bleached ..... 2.52 cts.per lb.  
100% of wgt.of pulp,  $\text{KMnO}_4$  as bleaching  
agent: ..... 9.75 cts. " "  

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Cost of white paper: 12.27 cts. per lb.







